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RESTRICTED VISIBILITY LAND COMBAT ANALYSIS – SUMMARY AND OVERVIEW (U)

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ABSTRACT

(U) This report presents a summary and an overview of a study addressed to the problems of restricted visibility land combat (RVLC). Recommendations are derived for potential ARPA research and development programs that would impact on the capability of the U.S. Armed Forces to conduct and support midintensity (no nuclear weapons) land combat in the European theater of operations where tactical or environmental obscuration to vision is a factor. The overview attempts to present an objective discussion of some of the salient land combat problems under restricted visibility conditions that emerged in the course of the work.

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PREFACE

(U) This report presents a summary of the work that Stanford Research Institute (SRI) has done on the subject of land combat and the support of land combat where restrictions to visibility such as smoke, night, bad weather, and battlefield obscurations are a significant operational factor. The summary covers work done under Contract DAAH01-72-C-0836 and closely related work that was done under SRI's R&D program. The focus of the study was on midintensity (no nuclear weapons) combat between the Warsaw Pact and NATO Alliance Forces in the post-1980 time period.

(U) The work done under the ARPA contract included the sponsorship of a RVLC workshop (Workshop I) to provide initial guidance to the program, the study of position location and land navigation, the analysis of target acquisition and handoff, a survey of experienced combat commanders, and some preliminary work on battlefield illumination (BI) analysis. The work that was done as part of the Institute's R&D program included the study of battlefield identification friend or foe (BIFF) and the sponsorship of Workshop II where government and industry experts were convened and tasked to address problems of RVLC. In the interest of presenting a comprehensive summary on the subject of land combat under limited visibility conditions, the work done under contract and that produced as part of the Institute's program have been integrated.

(U) The purpose of this report is to present in Section I an overview of some of the major problems of RVLC and then to summarize in Section II the results of the work done in the course of the study. The overview is based on what was learned in the study, other recent reports

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on the subject, and on the proceedings of RVLC workshops that were convened as part of this research effort.

I OVERVIEW OF THE RESTRICTED VISIBILITY LAND COMBAT STUDY (U)

(U) This section of the RVLC final summary report presents an overview that is based on the workshops,* the selected tasks, the survey of the combat commanders,† and the many references that have been studied--particularly, several very valuable NATO reports concerned with limited visibility combat in Europe. The findings and recommendations of the individual study tasks are not repeated here although some reference to major conclusions may be made.

A. Selected Study Areas (U)

1. Background (U)

(U) On the basis of the recommendations derived in the first RVLC Workshop, position location and navigation, battlefield identification, and target acquisition and handoff were selected for study as critical problems in RVLC. The problem areas selected were substantiated in the survey of experienced combat commanders that was conducted and by the conclusions reached by the panel groups in the second Workshop a year later. A systems approach was used in that the threat was examined and current operational and technical capabilities were reviewed; then, based on an analysis of the requirements versus capabilities, program recommendations were derived.

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*(U) Summaries of Workshops I and II are presented in Appendices A and B, respectively.

† Appendix C discusses the findings of the survey.

2. Target Acquisition and Handoff (U)

(U) Requirements usually specify a sensor acquisition capability out to the range of the weapon to which the sensor is coupled. Yet in field exercises and in operational experience, detection and acquisition usually take place at much closer ranges. This is caused in part by line-of-sight (LOS) limitations.

(U) Most of the development effort is being directed toward sensors; very little to handoff. However, the fundamental problem in the land combat target acquisition process in the European theater is in the handoff of the information to direct fire weapons systems--tanks, antitank weapons, artillery, and aircraft. Improvement is dependent on a common grid system and on handoff techniques among the Services and among the NATO Alliance Forces in Europe.

3. Battlefield Identification, Friend or Foe (U)

(U) In BIFF, the equipment and technology--and to some extent the thinking--are dominated by the MARK XII aircraft IFF system because of the huge investment in equipment and funds that has been made. It is easy to understand why aircraft identification was the initial focus of IFF development. Aircraft identification is a serious problem at the speeds and distances involved. Because of the high mobility of aircraft, they can intrude in friendly airspace and must be sorted out from friendlies. In comparison identification of ground vehicles is reasonably easy. However, there is a lack of appreciation of the Soviet intent and capability to force a highly fluid battle situation in Europe where large numbers of armored and mechanized units will penetrate deeply and rapidly in a sustained attack at the maximum achievable pace at night and in poor weather. Identification by the location of a unit with reference to a fixed battle line will not work. A BIFF system will be essential.

(U) In contrast to the lack of interest in BIFF within the operating forces, both the workshops and the survey of experienced combat commanders singled out BIFF as a major problem. It was also recognized as a critical problem in recent NATO target acquisition and limited visibility combat studies.

(U) Three things are needed: an understanding of the BIFF land combat problem, a definition of requirements for a common system, and a determination of the level to which the system must be furnished. The NATO Alliance forces must also agree on the system because the very fluid, intense combat environment that can be anticipated in Europe will be the area of its principal application. A start on the solution of the problem might be for DoD to establish an ad hoc committee to address the problem. Membership should include NATO participation.

4. <u>Land Navigation</u> (U)

(U) Most development effort for navigation and position location is being expended for costly systems that will depend on electromagnetic (EM) radiation. These systems are being developed to meet more stringent location accuracy requirements than are necessary for tanks and APCs. A less expensive, self-contained system composed of a gyro compass, the vehicle odometer, a computer, and an appropriate continuous readout device can satisfy navigation and position location accuracy requirements for such vehicles.

(U) In the near term many of the man, vehicle, and aircraft tactical navigation systems are expected to be LORAN-dependent. A sophisticated enemy like the Warsaw Pact forces with a strong inclination and capability for electronic warfare (EW) can be expected to counter a navigation system like LORAN if most of our land and air position location, navigation, and even weapon delivery capabilities were dependent on it.

(U) The single important, common problem for navigation and position location systems in RVLC is the need for the users of these systems to interact with many other users. This implies the need for position reporting and a common grid. In the combat environment in Europe, automatic position reporting would be essential in night and limited visibility combat.

B. Warsaw Pact Night Combat Capability (U)

(C) There is substantial agreement that the Warsaw Pact capability for high tempo armor and mechanized operations at night is real. Warsaw Pact tanks and mechanized infantry combat vehicles are--and have been for some time--equipped with active IR night driving equipment. Large-scale field exercises that stress night operations are conducted each year. The move of armor and mechanized forces into Czechoslovakia was made entirely at night and without warning.

(C) Intelligence indicates that the USSR places great importance on the doctrine of conducting intense military operations at night. Under Soviet doctrine, night is a natural extension of daylight operations and continuity of attack must not be impeded for reasons of darkness or restricted vision. They stress that indoctrination and combat operations exercises continue 24-hours a day regardless of weather, terrain, or night conditions.

(C) Research and operational development of passive night devices has been actively pursued, and this capability can be expected to be fielded when it is developed. Extensive reliance on battlefield illumination for combat operations is expected. It seems characteristic that the USSR gets simpler, perhaps less capable equipment into the hands of its operational forces while the United States strives for advanced and more capable equipment that remains in research and development. This misconception of force development emphasis appears to be the cause of critical shortcomings in U.S. capabilities.

C. Continuous Combat Operations (U)

1. Discussion (U)

(C) The most significant land combat problem in the European theater is that of continuous combat operations. The USSR has elevated continuous combat operations to the level of one of the principles of modern combat, whereas the NATO Alliance forces have at best given it only lip service.

(C) The important point is that in a European conflict we must be able to fight where and when the enemy chooses. The Warsaw Pact forces have stressed the development of a capability for continuous combat operations. Unless we wish to have no alternative but a nuclear response, we must be able to fight at night and to meet the threat of unremitting attack pressure.

(U) Gaining a capability for sustained combat operations depends not only on the capability to fight at night and in adverse weather but also on much broader problem areas. The psychological and human factors are fundamental considerations. Machinery can be made to operate on a sustained basis; men cannot. Individual and unit training is essential to turning the fear and strangeness of night into a military advantage. The echelonment of forces is necessary so that fresh troops are cycled to the point of combat contact. Essential combat, combat support, and command and control functions must operate continuously.

(C) Despite paper emphasis on night operations in training directives and doctrinal statements, U.S. combat units have been reluctant to treat them as a normal course of action in the solution of tactical problems. Normal operations have followed a rhythmic pattern of intense day activity broken off at dark for replenishment, rest, and regrouping.

(C) The Department of the Army has no current or proposed programs on the subject of continuous operations. Further, no ongoing study deals with the broad range of problems that relate to human capabilities and limitations in continuous combat operations.[1*]

2. Warsaw Pact Doctrine for Sustained Combat Operations (U)

(C) Warsaw Pact doctrine emphasizes the importance of leading with armor on the main attack axes and attacking in strength in regimental-sized groups. The momentum of the advance is maintained by replacing leading divisions with fresh divisions held in the second echelon, coupled with sustained day and night operations to achieve maximum penetration. Closing tightly with Alliance forces deep into NATO-defended territory reduces the risk of tactical nuclear weapons being used against them.

(C) The extensive use of mounted infantry in their motorized rifle divisions (MRDs) and of heliborne units provides the Soviets with the high mobility required. The USSR is the first with a modern-tracked Mechanized Infantry Combat Vehicle (MICV), the BMP-76. They have had in inventory for many years large numbers of helicopters (such as the HOOK) that are capable of carrying large numbers of troops. These high mobility systems that are night capable give the Warsaw Pact forces flexibility because the second echelon can be widely spaced and a considerable distance from the first echelon. Positioning of relief elements is therefore not dictated by space.

(C) Warsaw Pact ground forces are well-trained and equipped for night operations. Their doctrine for these operations is to keep

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*References are listed at the end of this report.

the maneuver simple and not to change direction. By night, infantry may lead and remain in their MICVs until forced to dismount. They must continue the attack pressure at night to achieve their planned rate of advance of 100 km in 24 hours.

(C) The Warsaw Pact armies currently have a basic night-fighting capability. Tanks and infantry are equipped with active IR aids; once the attack is started, all systems including direct white light are used. Warsaw Pact forces place priority on the development of night-fighting devices and will introduce passive night-viewing equipment into all first echelon combat units.

(C) Airborne assaults of division size could be used against the Northern and Southern Regions of Europe. In the Central Region they are more likely to be directed against the rear areas. Heliborne forces may also be used in all weather in support of attacks to seize objectives in advance of the main forces.

3. NATO Alliance Operational Requirements (U)

(C) The Warsaw Pact forces have demonstrated their capability for large mobile operations at night and for advanced weapon development. No advantage remains for smaller forces in opposition except superiority in quick, flexible response; accelerated decision and communications processes; and superb small unit mobility.

(C) Against a well-armed, well-disciplined, well-trained, numerically superior enemy force, the Allied forces must develop methods of effective decentralization of command, more alternative responses within nonnuclear limitations, and highly mobile small unit tactics capable of night and limited visibility operations. These must be coupled with the training, tactics, and organization that will enable sustained combat operations.

(C) Multiple night air cavalry penetrations by small battle units equipped with night vision capabilities and light portable armor-penetrating weapons could cause extensive disruption of communications and supplies. The application of air cavalry concepts under enemy air superiority and against large enemy armored thrusts deserves study.

(C) The problem of quick response decision making at the upper levels of Allied forces command needs research attention consistent with the requirement for rapid war developments in sustained combat operations.

(U) Fluid continuous operations will require constant surveillance of the battlefield in near real time. This will entail extensive use of advanced computers, data links, and communications procedures and the integration of all sensor and intelligence-gathering systems.

(U) In combat service support, transportation requirements will be increased and thus require more rapid movement over greater distances. Therefore, greater dependence will be placed on air transport of material, ammunition, personnel, replacement parts, maintenance units, and POL.

(U) Continuous use of vehicles, weapons, and material will result in greater maintenance requirements. Concepts to improve maintenance will include equipment designed for ease of maintenance, modular construction, self-contained fault isolation, throw-away components, and advanced organizational units such as air transportable maintenance vans.

(U) Effective fire support round-the-clock is a requisite to continuous operations calling for all-weather fire support systems. Emphasis needs to be placed on aerial fire support both from the standpoint of air defense and close air support (CAS).

D. Close Air Support (U)

(U) In the intense and fluid combat environment that can be anticipated in a European conflict between NATO Alliance forces and the Warsaw Pact nations, the ground combat commander could expect very limited air support at night and virtually none under poor weather conditions. Fundamentally, the problem lies in all aspects of the command and control system and in the doctrine of aircraft control and allocation. The cumbersome command and control system of CAS is archaic and would crumble in European combat where command and control would have to take place in near real time. However, in every aspect of the night and all-weather air support mission--air space and air traffic control, IFF ground to air, position location, target handoff, weapons and weapons delivery--our capability is poor to none. Systems such as the attack helicopter, and in some respects the V/STOL Harrier, may be better suited to the fluid and all-weather requirements of European combat. However, control, maintenance, and logistics problems would be compounded; survivability is an unanswered question.

(U) Finding targets is not the problem. In sustained combat in Europe, thousands of tanks and armored personnel carriers (APCs) would be involved; however, because of increasing costs, aircraft numbers would be decreasing. So there must be an increased sortie rate. But the pilot-to-seat ratio, which is currently about 1-1/2 to one, is inadequate for a high sortie rate. A high sortie rate also requires a base close to the unit supported and a tight real-time command and control system.

(U) Night and all-weather CAS weapon delivery capability does not exist except in a few very costly aircraft such as the A-6 and the F-111. Some capability is available in the TPQ-10 and the successor TPQ-29 radar bombing systems; but these must literally be surveyed in, aircraft

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are vulnerable while being controlled, and the system cannot be used effectively against moving targets.

(U) Control of the air is in serious doubt. The ground commander could expect to be left to his own resources because aircraft would be taken up with the counterair operations and interdiction.

(U) In the current system, one FAC per battalion must control CAS aircraft. When a battalion front was 1 km, this was sufficient. In a fluid battle environment, the battalion front is 10 to 15 km and therefore beyond the capability of the FAC.

(U) Fundamentally, in close support at night, a key problem is "Where am I and where are you?" There is no current capability for integrated position location, handoff, and designation in all-weather conditions. In fact, we are so far from an all-weather CAS capability that it is difficult to define the fundamental problems.

(U) An integrated study of the CAS problem must be done not only to reveal problems of command and control and those of aircraft allocation but also to focus attention on the problems that are inherent in intense combat operations at night and in adverse weather in Europe. No single problem can be identified nor can a technical solution be defined that could substantially improve our capability for the support of land combat under restricted visibility conditions. The command and control system is clearly a fundamental issue that must be resolved. Moreover, technical and operational capability at each phase of an all-weather CAS is so poor or nonexistent that a systems approach to the problem must be taken, if only for the reason of economy of effort allocation.

E. <u>Built-Up Area Warfare</u> (U)

(U) The Warsaw Pact doctrine is based on the concept of unremitting attack pressure by large numbers of armored and mechanized infantry units to penetrate as rapidly and deeply as possible. Anything that can be done to delay, to put obstacles in the path of the attack, or to channel it where it will bog down has a high goodness factor. Armor, especially in large numbers, needs room to operate. If the attack can be forced into the cities in Europe rather than be allowed to go around them, considerable advantage could accrue to the U.S. and NATO Alliance forces in the resulting built-up area combat.

(U) Military equipment--tanks, tank guns and fire control systems, target acquisition devices, infantry combat vehicles, and artillery--are all designed and intended for field use. They lose much of their advantage and, in fact, are liabilities in the city. Tank guns, for example, have a very limited elevation angle and cannot be brought to bear on the upper floors of tall buildings that are close. If an avenue is blocked, all the tanks and combat vehicles will be stacked up and immobilized. While they are jammed up, they will be vulnerable to attack by combat units within the city and outside support such as air attack. Attack helicopters could be especially effective if they could maneuver into attack position and take advantage of the cover that buildings would provide.

(U) The NATO Alliance soldier is familiar with urban surroundings and can perhaps be expected to be more adapted to combat in the city, block-to-block, and within buildings than his Warsaw Pact counterpart. Night and limited visibility add still another dimension where familiarity with the surroundings is an advantage to the defender.

(U) This concept of built-up area warfare in the context of NATO defense against the Warsaw Pact threat needs to be examined. Means for

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channeling massive armored attacks into cities should be identified. The significant influence of limited visibility and the capability requirements derived therefrom must be identified. Advanced concepts, doctrine, training, and equipment for combat in the cities might prove to be of fundamental importance in a conflict between Warsaw Pact and NATO Alliance forces.

F. Standoff Combat (U)

(U) For effective combat at night and in limited visibility, advanced technology equipment is essential--sensors for surveillance, detection, observation, and target acquisition; battlefield identification devices, position location, navigation, and position reporting systems; handoff data links; command, control, communications, and battlefield management systems to integrate the essential battlefield functions and to maintain an awareness of the status and location of the many units on the battlefield. This equipment not only enables combat at night and in restricted visibility but also provides the capability for standoff combat. An advanced concept in warfare that needs examination is based on using the forward elements as designators for supporting weapons at standoff ranges.

(U) At present, in a night combat situation, infantry units must meet a tank attack with weapons equipped with night sights, such as TOW, DRAGON, and LAW. The doctrinal concept in question here is that the target acquisition device and the weapon are in the same weapon system. The most expensive element (other than the man) is the night sight. Problems in handoff between direct firing and supporting weapons have not been solved; in fact, in most cases, they have not even been addressed. The infantryman is essentially the complete combat system from the detector to the one who fires the weapon. In fact, he is usually responsible for transporting the weapon to where it is ultimately used.

(U) The concept in land combat that emerges as the logic of the situation is examined is to use the forward elements as target designators. Precision-guided munitions like HELLFIRE--the Army's attack helicopter "fire-and-forget" laser-guided antitank missile--and laser-guided bombs depend on a forward observer to designate the target. The equipment essential for night combat is expensive and sophisticated.

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It cannot be provided to every combat element. The thrust of advanced combat concepts should be to equip selected infantrymen as a skilled and trained target designators equipped with advanced technology systems that will enable each one to locate himself precisely, to acquire and identify targets, to transmit his position and that of the selected target to a battlefield management system, and then to designate or mark the target for a supporting weapon system.

G. Technology and Equipment Development Overview (U)

(C) An analysis of technology and equipment currently available reveals that available capabilities have not been fully exploited. Little or no use except for night defense has been made of available devices. Current capabilities and interactions with other weapon systems in an operational role are not even fully known. Although current technology has been incorporated to some extent into working hardware, long-term evaluation is required to determine the extent to which it will perform in specific limited visibility conditions. Weapon systems and sensors such as unattended ground sensors (UGSs) and radars should be considered as part of an integrated system. Data requirements at the various levels of force structure in night and sustained combat are relatively undefined. It is not known what integration and interfacing through suitable data links are necessary in the modern 24-hour battle against a sophisticated enemy.

(C) The constraints and driving motivation in the development and selection of new technology and the performance required of weapon systems and sensors are dependent on the specific application in night and limited visibility combat. In new technology, visible, image intensifier, and near-IR devices are limited by Rayleigh and nonselective scattering in the atmosphere. Performance improvement can be expected from image tube development, and considerable improvements are taking place in white light sources that can be used for auxiliary illumination. The spectral response of image intensifiers is being pushed out toward 1.6 μ when it should be possible to take advantage of night sky illumination. Light augmentation by laser and gating techniques will be further developed and investigated. Thermal imagers are limited by water vapor in the atmosphere that causes lack of contrast. Over long ranges, atmospheric density and temperature variations can cause shimmer and

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scintillation. However, new materials and components are being developed to improve performance at room temperatures. A slow improvement in radar techniques can be expected, but extensions of the frequency band out to 140 GHz would need considerable investment. An atmospheric window at 95 GHz may be useful in limited visibility combat applications. Signal processing and data presentation should produce valuable improvement in future systems. In all areas, size, weight, and power consumption can be reduced. However, the size of energy-gathering components such as optical objectives and radar antennas cannot be much reduced without considerable loss of performance.

(U) In the final analysis, requirements for advanced technology programs should be based on actual combat experience, but large-scale field exercises can provide essential guidance in the absence of relevant combat experience. A well-constructed study can also establish a basis for understanding what must be done in operational testing, in training, in technology, and in weapon system development to achieve a capability for night, weather, and sustained operations.

II SUMMARY OF THE RESTRICTED VISIBILITY LAND COMBAT STUDY (U)

A. Introduction (U)

(U) Early in the study, RVLC Workshop I was convened with government and industry experts in tactical warfare. The purpose of the workshop was to assist SRI and ARPA in defining the principal problems of RVLC and to suggest an initial ARPA tactical technology program that would improve U.S. capability for land combat under these conditions.

(U) On the basis of the proceedings of the workshop, SRI studied the following subject areas.

- Position Location and Navigation of Land Combat Vehicles
- Battlefield Identification Friend or Foe
- Target Acquisition and Handoff
- Battlefield Illumination Analysis.

(U) A survey of experienced combat commanders was also conducted to identify critical problems of ground combat operations under restricted visibility conditions.

(U) In the final phase of the RVLC study, a second workshop was sponsored. Again, government and industry experts were convened to work in panel sessions on the problems of land combat under restricted visibility conditions. The purpose of this workshop was to review the work that SRI had done in the selected problem areas listed above and then to provide the opportunity for panel groups to discuss the problems attendant to RVLC.

(U) The sections that follow present a summary of the results of selected study areas. A brief summary of the proceedings of the workshop can be found in the appendices.

B. Threat (U)

(U) The focus of the study was on midintensity combat (no nuclear weapons) between the forces of the NATO Alliance and the Warsaw Pact nations in Europe in the 1980 time period.[2]

(C) The Warsaw Pact armored forces have a numerical advantage of at least 3:1, but it could easily be increased to 5:1 in the areas of the main armored thrusts. In tactical aircraft, a similar numerical advantage exists so that air control and even local air space control will be in doubt and, in fact, on the basis of the numerical advantage in aircraft and the numbers and types of organic tactical air defense weapons, the advantage may belong to the Warsaw Pact forces.

(C) Warsaw Pact doctrine emphasizes the importance of leading with armor on the main attack axes and attacking in strength in regimental-sized groups. The momentum of the advance is maintained by the replacment of leading divisions with fresh divisions held in the second echelon and sustained day and night operations to achieve maximum penetration. The risk of tactical nuclear weapons being used against them is reduced by closing tightly with Alliance forces deep in NATO-defended territory.

(C) Soviet tactics call for aggressive reconnaissance to locate gaps for exploitation in an attack from the march. A new dimension will be added in the wide use of tactical airmobile operations.

(C) Airborne assaults of division size could be used against the Northern and Southern Regions of Europe. In the Central Region, they are more likely to be directed against the rear areas. Heliborne forces may also be used in all weather in support of attacks to seize objectives in advance of the main forces.

(C) The Soviet basic maneuver unit is the regiment, which is larger than the U.S. battalion. A Soviet tank division (TD) consists of three tank regiments (TR) and one motorized rifle regiment(MRR). The motorized rifle division (MRD) has three MRRs and one tank regiment. A TR has 251 vehicles of which 93 are tanks and 6 are APCs. A MRR has 322 vehicles of which 31 are tanks and 66 are APCs. A front line regiment with this and associated equipment would cover an area approximately 5 to 7 km in width and 10 to 15 km in depth. Vehicles could be expected in platoon groups spaced with approximately 50 m between vehicles.

(C) The USSR expects that any future war will be characterized by wide dispersion of combat elements, great fluidity of the battlefield, a high degree of mobility for the combat elements, sudden changes in the situation, continuous operations day and night, and the predominance of meeting engagements as the common type of combat.

C. Position Location and Navigation of Land Combat Vehicles[3] (U)

1. Discussion (U)

(U) Current capabilities under blackout conditions are limited to inspection of standard military maps and observation of well-defined landmarks while the vehicle is moving along roads. When a vehicle is traveling cross-country and well-defined landmarks are absent, reliance for direction is on a hand-held magnetic compass. To obtain direction, however, the vehicle must be stopped and a crew member must dismount and walk some distance from the magnetic mass of the tank before a reading can be taken; this is a time-consuming and low confidence procedure under blackout conditions.

(C) A platoon would be considered the smallest tactical unit that would operate autonomously in Europe; therefore it would have the most stringent location accuracy requirements for the purpose of finding its assigned area. In conventional warfare in Europe, a platoon can be expected to occupy an area that is typically 300 to 500 m along the front, about 150 to 250 m on either side of the assigned center point, and about 100 m in depth.

(U) SRI's analysis of the mapped terrain features, towns, and road networks of Western Europe indicates that few areas can be traveled cross-country over 6 km without crossing map-identifiable roads.

(U) Recognition of landmarks for navigation checkpoints during off-road operation requires greater range than the range for obstacle avoidance. The fire control devices for tank main armament should assist in landmark recognition.

2. Conclusions (U)

(U) Most development effort for navigation and position location is being expended for costly systems that will depend on EM radiation. These systems are being developed to meet more stringent location accuracy requirements than are necessary for tanks and APCs. A less expensive, self-contained system composed of a gyro compass, the vehicle odometer, a computer, and an appropriate continuous readout device can satisfy navigation and position location accuracy requirements for such vehicles.

3. Major Requirements (U)

(C) The following major operational requirements for movement under restricted visibility conditions have been derived:

- Navigation to permit off-road travel from a known point of departure for a distance of up to 6 km is necessary with a radial error at the intended point of arrival not to exceed 100-m CEP. This point-to-point navigation accuracy requirement is consistent with the expected travel distances between well-defined roads in Europe and typical dimensions of areas to be occupied by platoon-size armored units.
- Cross-country movement is not always possible along a straight line; therefore, to verify position en route, visual checks against map-registered landmarks will be necessary from time to time. For consistency in meeting the navigation requirement stated above, position location accuracy while en route between the known point of departure and the intended destination should not have a radial error greater than 100-m CEP.
- Vehicle commanders require small expendable items for use in designating the desired deployment position of their vehicles.
- Restricted visibility aids for drivers of tanks and APCs require vision to a range of at least 30 m. This requirement is based on available test data for highway driving.

4. Equipment and Technology (U)

a. Electromagnetic Systems (U)

(U) The survey of EM systems did not reveal a single system currently available, designed, or used for the performance of ground vehicle position location. However, EM technology, particularly from and ongoing for aircraft systems, is available and well-in-hand to provide land combat vehicles with these capabilities. A spectrum of current, planned, and conceptual systems and techniques that are applicable to the position location function of land combat vehicles was examined.

- Non-LOS, limited low frequency (LF), and very low frequency (VLF) systems of the LORAN, Omega, and Decca types can be received by land vehicles over most types of masking terrain.
- Position location signal sources using UHF (LOS propagating) signals must transmit from unrestricted, LOS elevated platforms such as airborne vehicles or satellites. System coverage provided by a suitable set of signals depends on the deployed height of the signal sources and other factors.
- Related types of systems and concepts are also included in the review of EM systems. These include:
  - The Long-Range Position Determining System (LRPDS) for accurate artillery survey.
  - A spectrum of moving target locating radars.
  - An Automatic Convoy (Ground) Control System (ACCS).

b. Inertial and Compass-Aided, Self-Contained Systems (U)

(U) Inertial navigators represent a large subset of the current and near-future, self-contained systems. Both inertial and aided inertial systems, subsystems, and concepts for application in land vehicle navigation and position location were detailed in the study. Airborne

(U)

inertial navigation systems were examined for possible application in ground vehicles. The complexity and constraints of cost, capabilities, and time for such adaptation were revealed; for example, seven to ten years are required to design, develop, test, and evaluate the modification of an airborne inertial system for satisfying operational requirements for ground vehicles under restricted visibility conditions. However, one particularly capable but relatively high cost system that uses 1966 airborne position locating equipment technology is the Position and Azimuth Determining System (PADS); it is used for accurate artillery location. PADS is based on a Navy airborne inerti ' system and could conceivably be modified to a lower cost, aided inertial navigation system.

(U) An extremely promising land-vehicle-mounted, compass-aided system called NAVAID was identified and detailed. Although not potentially as accurate as PADS, the Canadian-made NAVAID offers adequate capabilities through a dual-compass system (gyro and magnetic) for most ground vehicle position location functions. It is comparatively much lower in cost than PADS and is currently undergoing tests in Canada. Two of the NAVAID systems are expected to undergo U.S. Army testing at Project MASSTER in the spring-summer of 1973.

(C) Self-contained, aided inertial systems generally use devices that measure velocity, altitude, local vertical and gravity anomalies for error compensation (artillery survey). Aided inertial systems use one or a combination of devices, shown in Table 1, to improve the capabilities of pure inertial systems.

(U) The promise of improved and new gyros in many applications that use mechanical gyros prompted an examination of laser gyro characteristics,capabilities, and acquisition cost.

Table 1

(C) SELF-CONTAINED SYSTEM DEVICES (U)

Device	Function	Nominal Accuracy
Odometer-timer	Velocity measurement	1 percent
Laser velocimeter	Velocity measurement	1 percent
Doppler velocimeter	Velocity measurement	0.1 percent projected
Barometer	Altitude measurement	±10 m
Inclinometer	Determine local vertical	0.1°
Gradiometer	Identify gravity anomalies	Currently in development; data not available

c. <u>Celestial Navigation</u> (U)

(U) An examination of position location by celestial observations revealed that this system offers no promise for tactical land mobile operations for battalion-size (or smaller) units under restricted visibility conditions. Even under ideal conditions, the accuracy obtainable by means of celestial observations at dawn/dusk (horizon not observable at night) is of the order of 0.25-mi rms. The position accuracy obtainable by using an aircraft-type bubble sextant is more of the order of 1- to 2-mi rms under excellent nighttime conditions.

5. <u>Recommendations</u> (U)

(C) There are two major program recommendations: the development of a low cost, self-contained navigation and position location system for land combat vehicles for use at platoon level; and the support of limited in-house funding by industry on laser gyroscope R&D. These two program recommendations are amplified in the following paragraphs.

(C)

- Undertake development of an accurate, reliable, and economical self-contained navigation system for land combat vehicles. The current NAVAID system may offer the possibility of a limited interim solution to the land vehicle navigation problem; particularly questionable are the design and deployment of the magnetic compass and the currently stated reliability. However, the NAVAID system, developed by Aviation Electric Co. of Canada, is currently undergoing operational testing in Canada for the Canadian Army, and two systems are being made available for evaluation on a no-cost basis to the U.S. Army. This presents an opportunity to work closely with the program manager of Navigation and Control Systems (NAVCON), U.S. Army Electronics Command, Fort Monmouth, New Jersey; and MASSTER during the conduct of a field demonstration of the two NAVAID systems requested and offered to NAVCON for assessment under clear day and restricted visibility conditions. Operational evaluation of this economical and marginally adequate land vehicle navigation system should be closely monitored.

  Enter early into a close association with these organizations. A further suggestion is that ARPA participate in the planning of the field tests to ensure the performance and collection of comparative field data appropriate to ARPA needs (under various night conditions and unfamiliar terrain) that should supplement the procedures and output that characteristically satisfy MASSTER requirements. In addition, it may be necessary for ARPA to support funding to ensure continuity of the program and timely completion of the planned testing and subsequent exposure of the results. The investigation and possible adoption of a self-contained system is not a widely accepted solution to the land vehicle navigation problem, even within the Army. Test results may indicate that an ARPA-supported modification or improvement program for NAVAID is adequate for U.S. land vehicle navigation requirements in Europe under restricted visibility conditions. However, even if NAVAID falls short of expectations, a firm basis is established for an ARPA program to identify the pertinent parameters and specifications for the design and development of a timely and operationally suitable, self-contained land vehicle navigation system.

(C)

- Strongly support development of a family of laser gyroscopes to replace the widely used conventional gyros, with application in a variety of sea and airborne, as well as land vehicle, navigation systems. Laser gyros offer several advantages that suggest a high potential program area for ARPA activity. While laser gyro accuracies are not expected to improve beyond the best of the mechanical gyros, the key requirements of long life, high reliability, and very short start-up and turn-on times, which have not been achieved in all operational and candidate gyros, would be greatly improved. Another advantage is that cost of production will be of the order of only 10 percent of current mechanical systems. As a rule of thumb, only about 15 percent of the navigation system cost is attributable to the gyroscope. Therefore, a significant savings may be achievable in the higher cost systems such as airborne and artillery surveying equipment. A lesser cost savings may be appreciated by laser gyro substitution in low cost land navigation systems like the previously mentioned NAVAID. However, the cost savings that result from reduced spares and lower maintenance requirements offered by the laser gyro should also be considered.

D. Battlefield Identification, Friend or Foe (U)

1. Discussion (U)

(U) The BIFF problem areas in midintensity combat in Europe were identified by developing a time-phased meeting engagement between Warsaw Pact forces and those of the NATO Alliance. It was clear that the Warsaw Pact forces have the intent and the capability to force an intense and fluid battle situation. Large numbers of tanks, mechanized infantry, organic air defense units, tactical air and heliborne infantry will be involved. The Soviet doctrine is to penetrate deeply as rapidly as possible in sustained and continuous combat operations around the clock. A fluid battle situation will ensue. After the attack develops, no established or static FEBA will exist. Identification of units based on their location relation to an established battle line will not be possible. In this intense and confused battlefield environment, a reliable BIFF system is required; at night and in restricted visibility, it is vital.

(U) The following BIFF problem areas were identified after an examination was made of the meeting engagement that had been developed:

- Individual or crew-served direct fire antitank weapons.
- Tank weapons.
- Remote ground and airborne sensors.
- Armored vehicle (self-contained) air defense.
- Individual man-portable (self-contained) air defense.
- Direct aerial fire support and CAS.
- Relationships with air traffic management and command and control systems.
- Security and vulnerability.

(U) A large number of military requirements statements and technological concepts that have been proposed were reviewed in the

(U)

study effort. They address most of the BIFF problem areas identified above. Some of the specified systems are in test and development on a low budget, fragmented basis in government laboratories and industry.

(U) On the basis of the review of these requirements statements and the study of the battlefield identification problems that evolved in the postulated time-phase meeting engagement, the following criteria for RVLC BIFF systems were developed:

- All-weather capability.
- Compatibility with other BIFF systems.
- High identification confidence.
- Light, small, simple components.
- High discrimination between targets in close proximity.
- Easy integration with other essential systems--command and control, target acquisition and surveillance, fire control.
- Ease of operation.
- Reliability.
- Self-testing.
- Indication that it is working--interrogating, responding, or analyzing a response.
- Automatic response.
- Low cost.
- High security and low vulnerability to enemy countermeasures (CM).

2. Findings and Conclusions (U)

(U) The Warsaw Pact forces can force an intense, fluid, and confused battle situation characterized by wide dispersion of the combat elements, a high degree of mobility, sudden changes in situation, continuous and sustained operations day and night, and the predominance of

(U)

the meeting engagement as the common type of combat. Battlefield identification with reference to an established FEBA or the location of the unit in accordance with a battle plan is not feasible. A BIFF system is essential in the European battlefield environment; it is critical at night and in limited visibility conditions.

(U) Because of the general lack of interest within the U.S. military services and the influence of the SEA experience, BIFF training and doctrine is primitive or nonexistent. There are a number of requirement statements for BIFF systems but very little support of their implementation. Some technology development efforts and concepts are being pursued in industry and in government laboratories, but these efforts are fragmented and low budget. Fundamentally, before technological development effort can be efficiently applied, an understanding of BIFF land combat problems, a definition of a common system, and the determination of the level to which the system must be furnished are clearly needed.

(U) When operational and functional requirements for IFF systems are examined, it becomes obvious that requirements can be widely different with combat application. As an example, the MARK XII aircraft IFF system, developed for air defense and air traffic control, is not readily adaptable to ground combat. It requires an L-band radar interrogator, and its discrimination between vehicles is poor. There are also the problems of clutter and battlefield obscuration. Ranges in land combat are much closer.

(U) A passive BIFF system--that is, a system not dependent on an active reply in the transponder or reflected energy sense--would be very useful in land combat. However, there is little potential for such a system. Another useful capability would be that of hostile target identification. Some air-to-air hostile target identification systems

(U)

that depend on computer recognition of the radar signature of an aircraft are in development and test, but this principle does not seem to be economically or technically feasible for ground-to-ground application. Therefore, a ground combat BIFF system must be very reliable so that targets that fail to respond with a friendly reply can be positively regarded as enemy targets.

(U) None of the current inventory or concept equipments that were evaluated met the requirements for secure use by the many users in a land combat environment. An all-microwave (interrogator and transponder) system seems to have the best potential.

(U) The use of a laser as an optical beam sharpener has significant disadvantages in the land combat environment: degradation by fog, dust, rain, smoke, and battlefield obscurations; the optical detectors must be kept free of dirt. Hybrid systems that use optical subsystems also have these disadvantages. In addition, they are more complex and costly.

(C) The MARK XII system for aircraft identification is now 11 to 12 years old. It has inherent L-band radar limitations for land combat applications (mentioned above) in target discrimination. Complex modifications have been necessary to improve system security and vulnerability. However, there has been very extensive investment in money and equipment in the MARK XII system. It has extensive air defense and air traffic control applications. The STINGER man-portable air defense system has already been tied into it and other battlefield air defense systems will be. Its extension into land combat applications is being studied. Because this IFF system has become so firmly established, any battlefield identification system must be complementary. Changes in IFF can therefore be expected to be transitional and evolutionary.

(C) The Electronics Command hybrid microwave/RF BIFF system is more suitable than the MARK XII for ground combat in restricted visibility conditions. It is somewhat limited by the security and vulnerability of the coded UHF transponder replies that it uses. However, a complementary mix with the MARK XII IFF would provide an interim or transitional solution to the multiuser problems in the European environment.

(U) A BIFF system must be capable of selecting a particular target from a group. A very narrow-beam millimeter wave interrogator and responder that use short transmission times and coded signals would be able to discriminate among close targets at night and in adverse weather. Also, because of the difficulty of detection, the enemy would be unlikely to try it. This kind of system might be an alternative to the MARK XII-hybrid microwave/RF BIFF system discussed above.

(U) Remotely Monitored Battlefield Sensor System (REMBASS) capabilities can be improved significantly by improving target classifiers used with remote UGSs. The feasibility of target classification with acoustic ground sensors has been demonstrated.

3. Evaluation of Current BIFF Systems and Concepts (U)

(U) Current systems with a battlefield identification function that were considered in the course of the study are presented in Table 2. The battlefield identification concepts that were reviewed are listed in Table 3.

(U) These systems and concepts were evaluated in the context of the battlefield problem areas (identified above in subsection D-1) and the BIFF effectiveness criteria (listed above in subsection D-1). The findings and conclusions presented in the next section were reached

Table 2

(U) CURRENT BIFF SYSTEMS, EQUIPMENT, AND TECHNOLOGY EXAMINED (U)

Application	BIFF Systems, Technology, Equipment
Ground-to-ground	Night vision and illumination systems Surveillance radars Optical battlefield IFF system Hybrid RF/laser IFF system Hybrid RF/microwave IFF system
Ground-to-air	Night vision systems MARK XII/MARK X (SIF) MARK XII supplemented IFF equipment Forward area alerting radar/rapid identification device (FAAR/RAID) Air traffic control radar beacon system, IFF, and MARK XII system (AIMS) Laser ranging and identification system (LARIDS) STINGER IFF system Signature analysis/processing systems
Air-to-air	Target recognition through integral spectral analysis techniques (TRISAT) Dual-mode recognizer (DMR) Target identification system, electro-optical (TISEO) Laser electro-optical system (LEOS)
Air-to-ground	Night vision and illumination systems Surveillance radars TISEO and LEOS Forward-looking advanced multimode radar (FLAMR) Lightweight interrogator transponder system (LITS) MARK XII/MARK X (SIF)

Table 3

(U) BIFF CONCEPTS EXAMINED (U)

Application	BIFF Concept
Ground-to-ground	Battlefield identification/recognition system (BID/R) Electro-optical techniques for remote identification of friendly armored vehicle, engine exhaust emissions Passive optical transponder Long-range RF BIFF system BIFF device (extrapolated) MARCES microwave IFF transponder MARCES electro-optic IFF transponder Remote ground and airborne sensors
Ground-to-air	MARK XII evolutionary concepts Potential areas for evolution of IFF-related systems and technology IFF-applicable air defense and air traffic CC system
Air-to-ground	LEOS FLAMR Spectral analysis of vehicle exhaust Millimeter wave radiometry (MMWR) Air support applications of ground BIFF systems

(U)

on the basis of that evaluation and the SRI study of battlefield identification problems. These led to the recommendations that are presented at the end of this summary.

4. Recommendations (U)

(U) The BIFF study produced the following recommendations:

- Develop and demonstrate a BIFF system for tank and antitank applications (man-portable, vehicle, and aircraft) based on a modification and extension of the STINGER IFF technology. Development of a two-frequency system should be considered for improved security and vulnerability. Large scale integration (LSI) should be used for electronic miniaturization. The technical risk in using LSI must be examined.

- Initiate a study of the use of the MARK XII and the ECOM hybrid microwave/RF BIFF systems mix for RVLC in Europe.

- Conduct a system requirements and engineering development study to define and configure a very narrow-beam microwave interrogator and transponder that operates in the millimeter wave region. The selection of operating frequency is important. Major factors to be examined include:

  - Antenna size and type.
  - Atmospheric absorption.
  - Microwave components (output power and receiver sensitivity).
  - Security of transmission.
  - Cost.

- Support development work on target classifiers for UGSs to include additional target signatures and multiple types of target sensor signature processing.

- Establish a committee of government and industry experts in tactical warfare to address BIFF land combat problems, to define a common system, and to determine the level to which the system must be furnished. Membership should include NATO participation, since the intense combat environment that can be anticipated in Europe will be the area of principal battlefield identification application.

E. Target Acquisition and Handoff (U)

1. Discussion (U)

(U) More than ninety requirements documents related to target acquisition cover the spectrum of sensors, platforms, position location systems, ranging devices, target designators, and seekers for precision-guided munitions. These stated requirements are generally oriented toward providing weapon systems with the capability of using their firepower at the maximum ranges possible; however, these are calculated from firepower and delivery considerations with little regard to target acquisition realism. Little guidance is given for target handoff to armor and infantry units--the maneuver forces that control most of the direct firing weapons on the battlefield.

(U) The individual night training in the recruit training program at Ft. Ord consists of 15 hours during the first eight weeks. An additional 40 hours was scheduled for the next eight weeks until this entire second eight-week period was discontinued and the recruit was sent directly to his unit. Unit training is left to the discretion of the unit commanders. Because of the overriding requirements for training and deployment of individuals to Vietnam during the past four or five years, almost no unit training in night operations (including target acquisition) has been given. Exceptions include the support given to MASSTER field tests by brigade-sized and smaller units of III Corps at Ft. Hood and the experimental helicopter pilot "OWL" teams at CDCEC at Ft. Ord in which the effect of training on the pilot's capability to fly nap of the earth at night is being examined.

(C) Although research and development of technology supporting systems for acquisition of land targets has been continuing,* the current Table of Organization and Equipment (TOE) STANO equipment as it is used operationally is probably inadequate. Only 8.46 percent of the targets were detected at an average range of 201 m by all sensors being used in the MASSTER II field test. Because U.S. current capability is so poor, a few incremental improvements attained through upgrading the inventory equipment performance could result in a significant improvement in overall target acquisition capability. Most of the TOE experiments are first- or second-generation night-viewing aids that lack the performance capabilities comparable with more expensive sensors under advanced development or in the conceptual stage.

(U) The military services are pursuing research and development of image intensifiers, IR devices, radars, lasers, television, and UGSs. UGSs should be useful in defensive situations and leave-behind operations if their false alarm rate can be lowered. A classification system for UGS that results in a reduced false alarm rate has been demonstrated, but further testing is required to substantiate initial promising results. Laser designators are being developed primarily in support of airborne weapon systems. Except for this, little capability or development effort exists in target handoff for direct firing weapon systems--tanks, antitank, and crew-served weapons. Very little work has been done in radiometry for target acquisition through haze and fog.

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*(U) In 1972 the work units were valued at $22,600,000, with 66 percent allocated for sensors and related technology; 9 percent for target properties; 7 percent for processing; 9 percent for human factors; 5 percent for test, evaluation, and field experiments; and 4 percent for miscellaneous.

(C) Currently, little doctrine and operational capability are available for conducting airborne target acquisition in direct support of ground troops engaged in RVLC. However, experimental programs such as the AC-130 gunship and the SEA Multisensor Armament System for Huey Cobra (SMASH), Image Intensifier System, Night Vision (INFANT), and Night Hawk helicopter systems offer encouragement for the development of operational near real-time target acquisition systems for night operations.

(U) The distribution of maximum ranges for ground-to-ground LOS has a large variance. A study of seven groups of potential air defense vantage points in West Germany indicates the expected range at which the probability of LOS equals 0.5 is about 1 km. During November through February, the visibility in Western Germany is below 3 mi for an appreciable percentage of the time (e.g., over 50 percent in Hamburg) and less than 1 mi for approximately 10 percent of the time.

2. Conclusions (U)

(U) Analysis of the areas summarized above has led to the following major conclusions.

(C) Warsaw Pact forces have a significant superiority in tanks and mechanized equipment. They are equipped and trained for night operations. Their doctrine calls for aggressive unremitting attack and penetration in continuous combat operations--day, night, and in bad weather. They can force a fluid, intense combat situation that will place extreme demands on our target acquisition and handoff capability.

(C) Equipment, doctrine, training, and organization in U.S. forces are inadequate for target acquisition and handoff at night and under limited visibility conditions. Unit training for RVLC in the U.S. Army is almost nonexistent. Current doctrine is not specific on how to use target acquisition resources and is especially lacking in addressing

(C)

handoff, particularly to armor and infantry systems--the most numerous on the battlefield.

(U) Target acquisition requirements are generally too stringent. Significant improvements in target acquisition could be attained by designing and fielding systems for acquiring targets at the ranges at which they can be expected to come within LOS of direct firing weapon systems. Research and development emphasis should be placed on sensor technology for direct fire ground weapons out to LOS ranges.

(U) Most important, not enough effort is being directed toward target handoff for these direct firing ground weapon systems.

3. Recommendations (U)

(U) To increase U.S. target acquisition capabilities in RVLC significantly, the development of an overall system that uses the correct balance between trained men and technological sophistication to constitute subsystems that detect, identify, and locate targets is desirable; it should also enable weapon systems to make good use of the target information generated. Such a system will depend on the integration of specific building block concepts.

(U) The recommendation of this study is that the following building block concepts be developed, tested, and implemented if they are shown to be feasible. The concepts are formulated to meet the situations and shortcomings stated in the above conclusions. In particular, the first four concepts were generated in response to the need for a better target handoff capability within the LOS constraints of the European environment. The fourth concept also extends the use of sensor systems designed for short range requirements to cover areas of interest to longer range weapon systems. The fifth concept is directed to the

(U)

doctrine and training need stated in the conclusions. Finally, the sixth concept is aimed at upgrading the capability and usability of ground surveillance radars--potentially the most useful type of sensor in bad weather.

a. Ground Vehicle Weaponsight Point System (U)

(C) Many RVLC engagement situations can be expected in which the U.S. armored vehicles will not have time to prepare range cards for their guns. To react quickly to incoming enemy vehicles, U.S. armored vehicles will have to locate quickly the enemy vehicles after any observer on the U.S. side has made the first detection of the enemy vehicles.

(C) A system can be conceived that is based on each weapon system having a position location and azimuth indication system, and on the observer (perhaps in another vehicle) having the capability to transmit digitally both his position and the target azimuth and range to the weapon system(s) that will fire on the target. The simple computer used in tracking the position of the weapon system would also be used automatically to solve the geometry problem and indicate the direction to point the weaponsight.* This, together with a laser rangefinder, would permit a rapid resolution of the fire control problem without precalculated range cards or reference to a map in the dark.

(C) If this concept proved feasible, then a follow-up effort could investigate the feasibility of slaving the weapon sighting

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*(U) A relatively inexpensive position location system (incorporating a simple computer) for ground vehicles was one of the main recommendations in SRI's Ground Vehicle Land Navigation Substudy on this contract.

(C)

system to the computer-calculated direction to the target. Human factors, command and control, and training should also be investigated for cases where the observer sees more than one target and hands off these targets to several weapon systems. An authentication system devised to prevent the enemy from using the system to direct our own firepower against our own units would have to be considered.

b. Multiple Target Designator (U)

(C) In RVLC, one observer will occasionally be expected to find large numbers of armored vehicles within direct firing weapon ranges but other nearby observers or weapon systems will not immediately detect the enemy vehicles. It is imperative that the enemy vehicles be destroyed immediately after initial detection; hence, little time should be lost in handing off the acquired target information to weapon systems that can kill the enemy armored vehicles.

(C) Laser designators that could simultaneously designate several of the vehicles within the detected group (50- to 100-m spacing assumed) with a differently coded designation for each vehicle could be provided for observers. The nearest available weapon system--be it tank main guns, antitank weapons, crew-served antitank weapons, attack gunships, or precision-guided artillery shells--capable of detecting the coded designation signals could immediately attack the designated targets.

(C) A description of a system concept for simultaneously designating three targets follows. A laser designator will be boresighted with a night vision device on a stable tripod or stabilized platform. A viewing screen for the operator will have a cross hair fixed in the center, and two joy stick controls can move the two additional controllable

(C)

cross hairs provided on the viewing screen. The operator will track the center vehicle by moving the entire device so that the center cross hair remains on the center vehicle. As he tracks the center vehicle, he will control the moveable cross hairs with the two joy sticks to make the controllable cross hairs remain on the two vehicles on either side of the center vehicle. This manipulation may take some practice on the part of the operator; but, with the appropriate "can-do" spirit that might be gained from nighttime training with such a device, it is probably a feasible task to ask an operator to perform.

(C) E h joy stick will control not only the movement of a cross hair on the viewing screen, but also the stops on a rotatable mirror that is used to direct the beam of the laser sequentially to each of the three targets. The beam would be modulated or coded to specific codes for each of the three targets, depending on which mirror stop is being used during the transmission. It could also incorporate a simple IFF code.

(U) With current technologies, a prototype with a laser in the visible light spectrum should be built and tested for both visually sighted weapon systems and laser-seeking, precision-guided munitions.

c. Passive Target Designation System (U)

(C) In cases where the forward observer should remain passive as long as possible and in the event the enemy learns to counter active laser designators effectively, the following concept for a passive target designation system should prove beneficial. Let us suppose that the observer who first detects the target is using a low-light-level television (pulse gated, to provide extra range in haze) or an image intensification device or far-IR scanner with a capability to

(C)

transmit its imagery as his detection system. The observer would have the capability to designate a target on his viewing screen by a light pen, a movable cross hair, or a movable light point. He could then transmit the picture that he is seeing, together with his coordinates and the bearing and range to the target, to the appropriate weapon system that would have a TV monitor with a light point (flicker mode optional) capable of picking up the same image being observed at the target position incorporated. The weapon system could be a direct-firing tank gun; antitank weapon system; close support aircraft--either helicopter or fixed wing; a remotely piloted vehicle; or artillery with terminally guided munition capability.

(C) A simple computer in the weapon system's vehicle could combine the position of the weapon system with the position location information transmitted to determine the direction in which the weapon system's detection subsystem should be pointed to find the passively designated target; also it could appropriately scale the picture for the weapon to target range. The detected target could be taken under fire directly or by the use of contrast-seeking, precision-guided munitions.

(C) To investigate the feasibility of this concept, the weapon system's display should consist of two displays: one for the transmitted imagery and the other for its own direct imagery. The operator could then compare the two displays side by side until he finds the target on his own system's imagery. If the system proves feasible, then consideration should be given to reducing the display size for combat vehicles by superimposing (perhaps in a different color) the display from the remote sensor onto the display of the weapon system's own imaging sensors. The operator could switch the transmitted picture on and off as he desires while he searches for the target on his own detection display.

d. Alerting Long Range Airborne Radar for Moving Targets (ALARM) Air Control System (U)

(C) The ALARM system can be used to monitor the movement of friendly units as well as to detect enemy moving targets. If the weather is such that an image intensifier or far-IR device can be used, then a friendly aircraft (manned or unmanned) could be vectored into the area of the enemy target with enough precision that its own imaging sensor could be used to detect and identify the enemy targets. For a remotely piloted vehicle, the remote operator should have the displays from the ALARM system and the aircraft imaging system collocated.

(C) If the vectored aircraft is an attack aircraft, then it could take the target immediately under attack. If the aircraft is a reconnaissance aircraft with a laser designator, then the imagery from that aircraft's night-viewing system could be monitored; a laser designator could be used to designate the target when attack aircraft arrive in the area. For reconnaissance aircraft, this system could be used to guide remotely piloted vehicles over areas in defilade from the ALARM system or where enemy stationary targets are suspected to be.

(C) The technology and equipment are available to test this concept. The ALARM system could be used as it is to direct a night helicopter such as Southeast Asia Multisensor Armament System for the Huey Cobra (SMASH) or Night Hawk against moving vehicles. If the concept proves feasible for a manned aircraft, then additional tests should be undertaken with both a high performance BQM34 derivative remotely piloted vehicle and the Remotely Piloted Airborne Observation-Designation System (RPAODS).

e. Doctrine and Training for Target Handoff (U)

(U) Each of the above four concepts requires coordination between sensor operators and weapon systems operators. In each case,

(U)

the basic procedure requires using information first obtained by an observer and then transmitted to a weapon system's operator. However, operational experience and experimental field exercises indicate that effectiveness of a system can be appreciably upgraded by correct doctrine and training for the personnel using the system.

(U) Concurrent with the development of such technological concepts as above, a program is needed to define alternative doctrine for using such systems and for assessing the effect of training on the utility of the resulting man-machine system. The results of such a program would be a recommended doctrine, specific training tasks, and amounts of training that should be accomplished by the operators.

f. <u>Ground Vehicle-Mounted Radar</u> (U)

(C) Radar is our only current fog and cloud penetrating, near real-time sensor that can be easily moved around the battlefield. However, current radars are in vehicles that cannot easily keep up with armored combat vehicles that must deploy the radars when they are being used. The setup time and breakdown time of some 30 min would be unacceptable in many fluid situations but especially on reconnaissance patrols. It would be particularly desirable for armored reconnaissance vehicles to have a capability for searching for enemy vehicles whenever the armored reconnaissance vehicle pauses to search an area that it is traversing.

(C) The problems entailed in mounting a radar on armored vehicles should be delineated, and a prototype should be built to test the effectiveness of a vehicle-mounted radar. The antenna could be elevated when in use and stored when the vehicle is in motion. The radar should be capable of almost immediate use after the vehicle stops.

(C)

The same radar could of course be used in a static defensive position where the armored reconnaissance vehicle is positioned at an observation point. For static use of the radar, some alerting signal for the operator is apparently needed whenever a target signal is sufficiently strong. The alerting feature would be less important on reconnaissance patrols, however, because the operator would be relatively more highly motivated during the short stops for searching the areas to be traversed.

F. Battlefield Illumination Analysis (U)

1. Background (U)

(U) The first RVLC Workshop recognized the need to gain a better appreciation of the actual battlefield environment at night and under conditions of reduced visibility. One of the workshop recommendations was to develop a midintensity RVLC battlefield model that will permit better understanding of interactions among systems and of spatial and temporal distribution of radiation transients. A model with the capability of real-world simulations of light levels, flashes, fires, and other significant visual perturbances during RVLC operations would provide useful program support for training, human adaptation, and equipment design. Accordingly, a portion of the RVLC analysis was directed to the problem of developing such an analytic procedure.

(U) A tentative survey of the literature showed that the experimental and theoretical work that has been done relates to selected aspects of the battlefield environment, e.g., terrain, vegetation, illumination, or weather, and their effect on a specific combat activity. These environmental factors generally were considered incidental in evaluating equipment, personnel, or specific combat procedures. The extent to which a combination of natural and man-made environmental factors affects battlefield activities, particularly in RVLC, does not appear to have been the subject of any significant research.

(U) The SRI work to date has provided a data base of relevant environmental factors and has produced a methodology for conducting a BI analysis that should be a significant step toward satisfying the need for a model of the RVLC battlefield.

2. Methodology for Battlefield Illumination Analysis (U)

a. Objective and Approach (U)

(U) The objective of the BI analysis is to develop a capability for presenting the total restricted visibility environment and integrating all factors as a basis for the analysis of RVLC technology and future technological concepts. Attainment of this objective will require the development of the following capabilities:

- Representation of an integrated BI environment (to include the natural, battle-induced, and artificial aspects of the environment that affect visibility) as a function of combat intensity and the activities of U.S. and opposing forces.
- Representation of sources of obscuration of visible LOS.
- Derivation of requirements for countermeasures.
- Evaluation of the effectiveness of technological systems within the total context of visibility factors.

(U) Performance of the following four tasks appears to be necessary to achieve the above objective:

- Task 1--Develop a data base of information and physical relationships applicable to the analysis of the battlefield illumination environment.
- Task 2--Develop a tool (tentatively called the matrix method) to derive subsituations of interest from battle situations that are amenable to quantitative treatment.
- Task 3--Create tactical situations of varying combat intensity tailored to the requirements of the BI analysis.
- Task 4--Perform the illumination analysis for the combat situations, based on the tools of Task 2 and the Task 1 data base, for the purpose of determining the effectiveness of technological systems in an integrated visibility environment.

(U) Considerable effort has already been devoted to the first two tasks. In addition, outlines of the Task 3 combat situations have been developed. The fourth task is based on the preceding tasks. Part of the fourth task concerns the generation of pertinent questions to which the analysis will be addressed. A start has been made on generating these questions, and more will be continually generated as better understanding of both the requirements and U.S. capabilities for RVLC is gained.

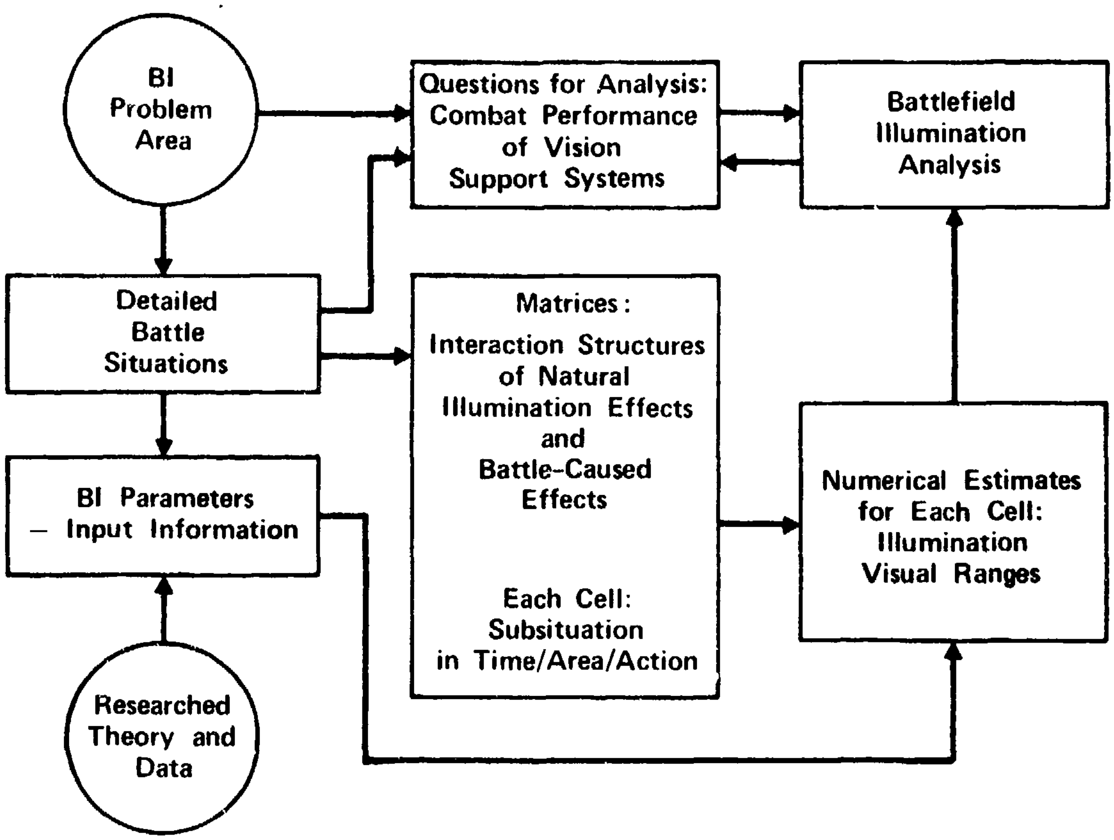
b. Data Base (U)

(U) The data base that must be developed is related to the following list of elements that will be parameters in the BI analysis.

- Ambient illumination in restricted visibility.
- Atmospheric attenuation effects (natural, battle-induced).
- Human sensors (aided and unaided).
- Battle objects/backgrounds.
- Battle incidental illumination.
- Artificial BI.
- Deliberate obscurations to vision.
- Potential other countermeasures.
- Tactics and doctrine.

c. Methodology (U)

(U) Figure 1 presents a flowchart methodology of the BI analysis. It shows how the study proceeds from the battle narrative and the data base to consideration of single aspects of BI to arrive at numerical estimates as the output for complex situations.



UNCLASSIFIED

FIGURE 1 METHODOLOGY FOR BATTLEFIELD ILLUMINATION ANALYSIS (U)

(U) This methodology entails the use of a tool designated as the matrix procedure. To break up the complex battle situation into manageable parts and to integrate the natural and battle-induced effects into an actual illumination environment, "interaction structures" in matrix form can be developed so that the cells of these matrices will be distinctly defined subsituations of the battle in time, area, action, and geometry of observers and objects. To construct these matrices, it is necessary to the variations that the questions center on and separate the events in time, area, action, and geometry so that each cell--that is, each specific subsituation--can be handled numerically with the available data.

(U) From each cell of the matrix, a direct matrix output is derived; that is, estimates of illumination values for specific areas or objects and given sources or source combinations of BI and visual ranges for specific objects and observers. For example, one cell may be the specific subcase of a time segment from a searchlight-aided attack against a tank platoon positioned against the background of buildings while the attacker commences crossing a river against the background of foliage at nighttime, with a half moon and light ground fog. This requires an estimation of illumination values for both sides--particularly the effect of the searchlights--as well as visual ranges of these attackers against the tank platoon. These values would be an example of direct results.

(U) Finally, to answer the questions that may be posed, an illumination analysis can be conducted on the basis of these numerical estimates for the different cells derived from the specific battle situations.

(U) The procedure outlined above is oriented to specific tactical situations and produces two types of results. First, for each

(U)

matrix cell, the direct results indicate a specific subsituation of the battle in time, area, action, and geometry--a set of results of illumination and visual range values as a function of those input variables that categorize the specific cell. Second, the derived results of the analysis provide answers to specific questions evaluated on the basis of the direct numerical results and the effectiveness of technological systems for the restricted visibility combat when the total visual battlefield environment is taken into account.

(U) The basic analytical tools described above are expected to provide the foundation for the development of more sophisticated and efficient methods of analysis. In addition, analysis results will be improved as better input data are acquired. Once a large enough sample of pertinent battle situations has been analyzed, sufficient results should have been obtained to recognize trends and to make recommendations for planning effective technological support in the total area of restricted visibility BI.

3. Uses of the Analtyical Tools (U)

(U) The analtyic tools described can be used to supplement STANO field experiments by:

- Characterizing the complex battlefield illumination environment.
- Quantitatively modeling the physical and technical relationships that affect battlefield illuminators and electro-optical sensors.
- Evaluating STANO equipment and the human observer in a given battlefield illumination environment.

(U) On the basis of the results derived by applying the analysis methodology to a large number of cases, decisions can be made on questions of operational procedures and force composition.

(U) Examples of the types of problems that might be amenable to the application of the battlefield illumination analysis tools are:

- The evaluation of the relative tactical performance of given image intensifier systems for various target types, backgrounds, and distances under varying natural and battle-induced light conditions.
- The most effective mix of middle and far IR imaging systems in varying ambient illumination conditions, changes in atmospheric obscuration, and enemy countermeasures.
- The impact of precipitation and fog on active illumination systems used in attack and defense.
- The tactical effectiveness of stabilized flares used for different attack objectives particularly in close combat where they might provide a light screen for friendly troops.

Appendix A

RESTRICTED VISIBILITY LAND COMBAT WORKSHOP I (U)

Appendix A

RESTRICTED VISIBILITY LAND COMBAT WORKSHOP I (U)

(U) A RVLC workshop was convened on 13-14 June 1972. Industry and government experts in tactical warfare met in panel work groups to develop preliminary guidance for ARPA and SRI in the study that had been undertaken. The purpose was to establish a basis for the initial ARPA tactical technology program directed to land combat and the support of land combat under limited visibility conditions.

(U) The number of attendees was limited so that the group would be small enough to interact and participate in a workshop environment. The membership represented a balance of experience and interest in RVLC problems. They were distributed in six work groups: Land Combat Operations, Battlefield Management, Target Acquisition and Surveillance (two groups), Weapons and Weapons Delivery, Navigation and Position Location.

(U) Program recommendations were sought in the following categories:

- Advanced technology
- Nth generation equipment
- Creative operational test and evaluation
- Study areas.

(U) The proceedings were presented in a report submitted on 5 July 1972.[4] Twelve problem areas were emphasized in all the panel discussions. These are summarized below in estimated order of priority:

(1) Position location, navigation, and position reporting systems.

(2) BIFF.

(U)

(3) Human factors (special training, endurance, psychclogical).

(4) Techniques for the rapid deployment of mines.

(5) Detection of sensors and countermeasures against sensors.

(6) EM spectrum control and management

(7) EM emissions from moving mechanical devices, equipment, and vehicles.

(8) Advanced antitank fire control.

(9) Vehicle control (displays and sensors).

(10) Advanced unattended ground sensors and countermeasures against such devices.

(11) Battlefield illumination (selective and area; covert and overt).

(12) Illumination countermeasures such as smokes and dispersants with selective windows.

(U) Table A-1 summarizes the problem areas and the research and development subject areas that were recommended by the panel groups. They are tabulated by program elements; that is, elements of land combat to which the recommendation pertains, by research and development subject matter, and by the program recommendation categories listed above.

Table A-1

PROGRAM AREAS OF POTENTIAL SIGNIFICANCE

Program Element	R&D Subject Matter	R&D Category
Night aircraft and helicopter operations; close air support	Development and systems integration of displays, navigation, and terrain avoidance equipment (radar, FLIR, others); position location and target hand-off.	Operational test and evaluation, equipment and systems development, studies
Air defense	Development of equipment and systems to counter the STRELLA air defense system, with primary emphasis on detecting the STRELLA missile launching	Operational test and evaluation, equipment and systems development
Antitank	Development of antitank weapons capabilities that are not primarily vested in guided missile systems that are sight limited under conditions of RVLC	Equipment and systems development
Battlefield environment	Development of a midintensity RVLC battlefield model that will permit better understanding of interactions among systems and of spatial and temporal distribution of radiation transients	Studies
Battlefield illumination	Development of selected spot and area illuminants, including flares, that operate outside of the visible spectrum (IR, microwave, other)	Equipment and systems development, operational test and evaluation
Battlefield IFF	Development of system requirements in terms of user function (weight, range, size); application of existing IFF techniques to existing ground and support aircraft communications systems; development of miniaturized transponders (active and passive), and cooperative beacons	Equipment and systems development, operational test and evaluation, studies
Common grid system	Development of concepts for a common grid system that can be used for target hand-off, BIFF, and operational coordination	Studies
EM emissions	Fundamental investigation of the physics of EM from equipment and vehicles to determine feasibility of detection under RVLC conditions	Equipment and systems development, advanced technology, studies
EM emission detection and countermeasures	Development of concepts, techniques, and equipment for detection and countering of laser target-acquisition devices that are resistant to enemy use of image intensification devices (LLLTV), and that will assist in the control of friendly emissions (one-way tank vision ports)	Operational test and evaluation, equipment and systems development, studies
Equipment mix and allocation	Analysis of the application, allocation, and tactical employment of sensors, displays, night vision devices, and related equipment that will elucidate problems of RVLC	Studies

Table A-1 (Continued)

Program Element	R&D Subject Matter	R&D Category
Frequency management	Definition of scope of problem of data transmission in the EM spectrum during midintensity RVLC; development of concepts for management and allocation of frequencies (sharing, spread spectrum, compression, time ordered)	Operational test and evaluation, equipment and systems development
High mobility RVLC tank killers	Investigation of effectiveness, feasibility, and costs of high mobility vehicles in the role of RVLC tank killers (ATV, advanced generation tanks, self-propelled guns, air cushion vehicles)	Operational test and evaluation, equipment and systems development, studies
Illumination countermeasures	Investigation and evaluation of the employment of measures that can be used to defeat enemy visibility capabilities (sensors, dispersants, aerosols with EM windows)	Operational test and evaluation, studies, advanced technology
Imaging systems	Analysis and development of concepts and equipment to improve human interface with displays; determination of relationships and utility of visual presentation compared with cues and symbology	Equipment and systems development, studies
Individual soldier sensor requirements	Determination of sensor requirements for individual soldiers under RVLC conditions	Operational test and evaluation, equipment and systems development, studies
Line of sight	Investigation and evaluation of employment of elevated platforms (RPV, balloons, drones, helicopters, fixed-wing aircraft, quiet aircraft) with existing or advanced sensors under RVLC conditions	Operational test and evaluation, studies
Mine warfare	Investigation and evaluation of tactical employment, delivery, dispersal, marking, and location identification schemes for mines under RVLC conditions	Operational test and evaluation, studies
Personnel and vehicle navigation systems	Investigations of all potential areas should be made since no adequate system has been defined or developed	Operational test and evaluation, equipment and systems development, advanced technologies, studies
Position/navigation system vulnerabilities	Investigation and evaluation of concepts and systems to reduce vulnerabilities of existing navigation/position location systems under midintensity RVLC conditions	Operational test and evaluation, equipment and systems development, studies
Position location	Development of concepts and systems that will permit the determination and reporting of accurate position locations	Equipment and system development
RVLC dependence on sensors	Determination of vulnerability of sensors to deception, jamming, and neutralization	Operational test and evaluation, equipment and systems development, studies
Tank fire control	Development of advanced target acquisition and fire control systems to ensure early-round kill capability for tank weapons (computers, Nth generation equipment, and range measuring devices)	Equipment and systems development

Table A-1 (Concluded)

Program Element	R&D Subject Matter	R&D Category
Target designation	Assessment of technologies of designation systems and viewing devices (laser, IR, microwave)	Operational test and evaluation, equipment and systems development, advanced technology
Target hand-off	Analysis and evaluation of equipment and systems for target hand-off tasks to determine commonality of procedures and equipment, position location/navigation, and common grid requirements	Operational test and evaluation, equipment and systems development, studies
Training	Analysis of problems of specialized technological training requirements, psychological stresses, and human endurance under RVLC conditions	Studies
Unattended ground sensors	Determination of feasibility of miniaturizing UGS equipment and systems (including power supplies) and application of new solid state receiver technology (advanced diodes, LEDs, miniaturized data processors)	Equipment and systems development
Vehicle control	Determination of concepts and equipment for visual aids and displays for vehicle control under RVLC conditions	Equipment and systems development, studies

Appendix B

RESTRICTED VISIBILITY LAND COMBAT WORKSHOP II (U)

Appendix B

RESTRICTED VISIBILITY LAND COMBAT WORKSHOP II (U)

1. General (U)

(U) This section presents a summary of the results of two days of workshop panel discussions by government and industry experts in tactical warfare.[5] They were brought together by SRI on 27-28 June 1973 and tasked to examine the problems attendant to the conduct and support of land combat under restricted visibility conditions in Europe against the Warsaw Pact forces in the 1980 time frame.

(U) Presented below are selected, abbreviated results of the discussions of the six panel groups that addressed the problem areas of Land Combat (two groups), BIFF (Target Acquisition), Target Acquisition (Handoff), Position Location and Navigation, and Atmospheric Effects. Only key topics have been included and briefly discussed in this summary in order to focus on the main elements of the RVLC problem.

2. Selected Tactical Land Combat Problem Areas and Program Recommendations (U)

(U) Continuous combat operations are the most significant land combat problem in the European theater. A study should be undertaken to examine the Soviet capability for continuous operations and the potential NATO response and to define the advanced tactical and technical concepts that would enable U.S. forces to meet the threat of continuous combat.

(U) The capability for CAS of the ground commander at night and in bad weather in the intense combat that can be expected in the

(U)

European theater is poor to nonexistent. An integrated study of the CAS problem should be done to examine not only problems of command control and aircraft allocation that have been exposed in several recent study efforts but also technical and operational problems in each aspect or phase of the CAS mission.

(U) Equipment that enables combat at night and under RVLC conditions also provides the capability for standoff combat. An advanced concept in warfare that needs examination is based on the use of the forward elements as designators for supporting weapons at standoff ranges. The surveillance, target acquisition, night observation, and designation devices with which the forward elements can be equipped are those advanced technology systems that are necessary for night and bad weather operation.

(U) In a future conflict in Europe, extensive combat in urban areas can be expected. Urban warfare should be studied from the perspective of training and doctrine that would take advantage of the U.S. soldiers' familiarity with the urban environment. Limitations of equipment that have been developed for use in the field should also be examined.

(U) Training is the most important element in achieving an RVLC and sustained combat capability. This subject area, particularly critical under an austere budget, should be examined to make the maximum use of training devices and advanced concepts in teaching.

(U) BIFF is recognized as a critical problem. User requirements, operational problems, and candidate technologies are not fully understood. An ad hoc committee should be established to address these problems.

(U) A lightweight, low cost, heading reference system is needed for position location and navigation purposes for the fo t soldier and land combat vehicles; this system would also have target acquisition system applications. Advanced technology needs to be pushed to achieve this capability. Evolutionary improvements in gyros will reach a point of diminishing returns and will therefore probably not provide the solution.

(U) Critical use is anticipated for remote piloted vehicles (RPV) in the severe air defense environment of a European conflict. Position location requirements and the means to meet those requirements under RVLC conditions have not been determined. This is an important problem area that is essential to the attainment of an RPV capability.

(U) An accurate position location system for remotely placed sensors is needed. This system must provide the position information of each sensor to a central data base.

(U) The effective handoff of targets is in many situations handicapped by a lack of understanding of the convergence of data from the raw data of the sensors to that needed by the weapon system. Basic studies need to be done to identify the essential factors in this process and how technology might aid in this convergence process.

(U) RVLC increases dependence on target acquisition sensors and surveillance systems. Methods should be developed for sensing and combating these Warsaw Pact systems, particularly the electro-optical devices that have such extensive application in the land battle. Means for detecting and locating enemy EO devices should be investigated.

(U) Millimeter radar offers the possibility of developing an imaging system that can image targets through weather in which other imaging sensors are ineffective. A window in the atmosphere exists at

(U)

95 GHz. The technology required for the development of a radar in the 95 GHz region should be supported.

(U) Methods of coordinating the displays of different sensors into a presentation containing appropriate symbology and map information should be explored.

(U) An inadequate understanding of the BI environment exists. An applicable data base is needed to assess the impact of restricted visibility conditions on the decision maker and on the equipment that he has for the conduct of the RVLC battle. The effect of temporal variations, both natural and battle-induced, is insufficiently known. Great uncertainty exists in the IR region. To address these problems:

- A study of the BI environment should be conducted; and a means should be developed for the analysis of temporal variations, natural and battle-caused. The methodology should be extended to the IR region.
- A data base should be developed for BI and transmittance and relevant atmospheric effects.
- A means should be devised for the battlefield commander to assess the meteorological conditions, their impact on the battle, and the resulting degradation of weapon system effectiveness.

Appendix C

SURVEY OF LAND COMBAT COMMANDERS (U)

Appendix C

SURVEY OF LAND COMBAT COMMANDERS (U)

1. Introduction and Summary (U)

(U) A survey was made of experienced combat commanders to identify the critical problems of ground operations under restricted visibility conditions.[6] The premise of the survey was that the difficulties cited would provide insight into the areas of greatest deficiency. Questionnaires were mailed to 151 Army and Marine officers who had had combat experience in World War II, the Korean War, or in the war in Vietnam. The responses were then analyzed.

(U) The combat commanders were asked about the kind of operations they preferred to conduct under both good and restricted visibility conditions. They were also requested to list problem areas related to the types of operations that they sought to avoid at night. Table C-1 provides a consolidated list of the operational requirements needed to overcome the difficulties cited by the respondents. The following operational requirements were mentioned most frequently:

Surveillance and target acquisition
Position location
IFF
Ground navigation
Control of ground units
Air traffic control
Air navigation.

2. Attitudes and Operational Factors (U)

(U) The statements and comments that accompanied the responses were more revealing than specific answers to the questionnaires. The

Table C-1

CONSOLIDATED LIST OF OPERATIONAL REQUIREMENTS

FOR EACH PROBLEM AREA IDENTIFIED BY SURVEY RESPONDENTS

Problem Area	Operational Requirements
Command and Control	Air traffic control Identification of friend or foe Control of ground units Maintain unit formations Provide terminal air traffic control over helicopters arriving and departing at the landing zone area Process and disseminate battlefield combat intelligence Maintain designated direction and rate of movement
Surveillance and target acquisition	Surveillance Target acquisition Emplace unattended ground sensors Detect natural and manmade obstacles (antihelicopter and antipersonnel) in landing zone capable of interfering with landing of aircraft and safe movement of troops from landing zone to assembly areas; includes obstacles not readily apparent to surveillance, e.g., sharpened stakes and mines In an air mobile assault, prepare alternative plans for approach to objective, and brief troops and aircrews; insert pathfinder teams into both primary and alternative landing zones; establish alternative helicopter flight routes, check points, and release points Night vision enhancement, dismounted troops Select type of illumination to suit tactical situation and own sensor capability Place illumination source in tactically advantageous three-dimensional position
Navigation and position location	Air navigation Position location Ground navigation Land helicopters (preferably in formation) on predetermined heading at touchdown Provide debarking troops with initial direction of movement relative to helicopter heading
Weapons delivery	Target designation Firepower observation Weapon flash suppression Employ air delivered explosives or other means to clear obstacles, including mines, without reducing utility of landing zone
Mobility	Terrain avoidance Air collision avoidance. Antiaircraft countermeasures Vehicle noise suppression (fixed wing aircraft, helicopters, and ground vehicles) Mark landing zone Install and identify markers at known positions to indicate route points, directions, and facility locations

(U)

clear impression evolved that night and adverse weather combat was not a strong capability of the U.S. forces. The respondents preferred not to conduct in-depth attacks, air-mobile operations, or attacks on prepared defenses under restricted visibility conditions. Preferred operations were: limited objective attacks, river crossings, withdrawal, relief, and patrols or ambushes. The limited objective attack, however, clearly reflected a rare willingness rather than a true preference.

(U) Many of the comments and recommendations of these experienced ground combat commanders on night and restricted visibility operations are particularly perceptive and were consonant with SRI's findings and conclusions from the study. Some of these comments are cited below:

- The key to good night operations is training. We do not do enough of it.
- A well-trained force is difficult to achieve because of the difficulty in maintaining personnel.
- We train primarily for daylight operations. Any combat operation can be performed better (more effectively) at night if troops are trained properly at night and have confidence in their ability.
- Too much dependence on sophisticated equipment can cause problems. Simple equipment in the hands of well-trained troops using adverse elements (night, restricted visibility) can achieve monumental results. (This is the basis of the Warsaw Pact forces capabilities for night and weather operations.)
- For success at night, a detailed estimate and plan and prior planning is essential. If you do what the enemy does not think is possible, you will have a tremendous advantage.
- Changes in maneuver are relatively simple in the daylight but sure disaster at night.

(U)

- The advantage at night is with whoever knows the terrain because of the extreme difficulty in maintaining control and coordinating fire support in poor visibility and the bedlam that results if control is lost.*

---

*(U) The corollary here is that if well-trained troops are provided equipment and procedures to locate their position accurately and maintain coordination and control, a tremendous advantage will accrue.

GLOSSARY

ACCS	Automatic Convoy Control System
AIMS	Air Traffic Control Radar Beacon System, IFF, and MARK XII System
ALARM	Alerting Long-Range Airborne Radar for Moving Targets
APC	Armored Personnel Carrier
BI	Battlefield Illumination
BID/R	Battlefield Identification/Recognition System
BIFF	Battlefield Identification, Friend or Foe
CAS	Close Air Support
CEP	Circular Error Probable
CM	Countermeasures
DMR	Dual-Mode Recognizer
ECOM	U.S. Army Electronics Command
EM	Electromagnetic
EW	Electronic Warfare
FAAR/RAID	Forward Area Alerting Radar/Rapid Identification Device
FLAMR	Forward Looking Advanced Multimode Radar
FLIR	Forward Looking Infrared
HELLFIRE	Heliborne Laser Fire and Forget
INFANT	Image Intensifier Systems, Night Vision
LARIDS	Laser Ranging and Identification System
LAW	Light Antitank Weapon
LF	Low Frequency
LITS	Lightweight Interrogator Transponder System
LEOS	Laser Electro-optical System
LOS	Line of Sight

LRPDS	Long-Range Position Determining Systems
LSI	Large Scale Integration
MASSTER	Modern Army Selected System Test Evaluation and Review
MICV	Mechanized Infantry Combat Vehicle
MMWR	Millimeter Wave Radiometry
MRD	Motorized Rifle Division
MRR	Motorized Rifle Regiment
PADS	Position and Azimuth Determining System
POL	Petroleum, Oils, Lubricants
REMBASS	Remotely Monitored Battlefield Sensor System
RF	Radio Frequency
RPAODS	Remotely Piloted Airborne Observation - Designation System
RPV	Remote Piloted Vehicles
RVLC	Restricted Visibility Land Combat
SIF	Selective Identification Feature
SMASH	Southeast Asia Multisensor Armament System for Huey Cobra
STANO	Surveillance Target Acquisition Night Operations
TD	Tank Division
TISEO	Target Identification System, Electro-optical
TOE	Table of Organization and Equipment
TOW	Tube Launched, Optically Sighted, Wire-Guided
TRISAT	Target Recognition Through Integral Spectral Analyses Techniques
TR	Tank Regiment
UGS	Unattended Ground Sensors
UHF	Ultra High Frequency
VLF	Very Low Frequency

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13. ABSTRACT

(U) This report presents a summary and an overview of a study addressed to the problems of restricted visibility land combat. Recommendations are derived for potential ARPA research and development programs that would impact on the capability of the U.S. Armed Forces to conduct and support midintensity (no nuclear weapons) land combat in the European theater of operations where tactical or environmental obscuration to vision is a factor. The overview attempts to present an objective discussion of some of the salient land combat problems under restricted visibility conditions that emerged in the course of the work.

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